Title

Future Professionalism on Ai and robotics to reduce pharmacological misuse in hospitals

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Abstract

pharmacological misuse in hospitals includes medication errors, inappropriate prescribing, incorrect dosing, drug–drug interactions, administration errors, and inappropriate use of

high-risk medicines. these problems can increase preventable adverse drug events, hospital morbidity, treatment costs, and mortality. artificial intelligence (ai) and robotics offer opportunities to reduce medication-related harm through computerized clinical decision support, automated prescription screening, medication reconciliation, barcode verification, automated dispensing, robotic medication preparation, and continuous monitoring. this research framework examines how ai and robotics can be integrated into hospital medication-use systems to identify and prevent pharmacological misuse. the proposed approach uses a mixed-methods hospital-based design comparing medication safety outcomes before and after implementation of ai-supported clinical decision systems and robotic medication-management technologies. primary outcomes include medication errors, inappropriate prescriptions, drug interactions, dispensing errors, administration errors, and preventable adverse drug events. ai and robotics may improve medication safety by providing real-time alerts, standardizing medication processes, reducing human transcription errors, and improving adherence to medication protocols. however, implementation requires clinical validation, cybersecurity, staff training, appropriate alert management, and continuous monitoring.

keywords: artificial intelligence, robotics, pharmacological misuse, medication errors, hospital safety, clinical decision support, automated dispensing, medication management

Introduction

medication-related harm is an important patient-safety problem in healthcare systems. medication errors can occur during prescribing, transcribing, dispensing, administration, and monitoring. the world health organization has identified medication safety as a major global patient-safety priority and

has emphasized the need to reduce avoidable medication-related harm.

pharmacological misuse in hospitals may include prescribing a drug without an appropriate indication, selecting an inappropriate dose, failure to recognize allergies or contraindications, clinically important drug–drug interactions, duplication of therapy, incorrect administration, and inappropriate use of high-alert medications. these problems may be particularly difficult to prevent in busy hospitals where healthcare professionals manage large numbers of patients and medications.

artificial intelligence can analyze large quantities of clinical information and identify potentially unsafe medication patterns. ai-supported clinical decision support systems can provide alerts for allergies, interactions, dose problems, duplicate therapy, renal-dose adjustment, and other prescribing concerns. machine-learning approaches may also help identify patients at increased risk of adverse drug events.

robotics provides another layer of medication safety. automated dispensing cabinets, robotic dispensing systems, robotic medication preparation, and automated medication-delivery technologies can reduce manual handling and standardize medication-management processes. barcode medication administration can additionally support verification of the correct patient, medication, dose, route, and timing.

the objective of this research is to evaluate the potential effectiveness of ai and robotics in reducing pharmacological misuse in hospitals and to develop a practical framework for their implementation.

Methods

Study design

a prospective mixed-methods hospital-based study can be conducted using a pre-intervention and post-intervention design. the study can compare medication-safety outcomes during a baseline period with outcomes after implementation of ai-supported medication management and robotic medication systems.

Study setting and population

the research can be conducted in selected hospitals containing emergency departments, outpatient departments, intensive care units, medical wards, surgical wards, and hospital pharmacies. the study population may include hospitalized patients receiving medications, physicians, pharmacists, nurses, pharmacy technicians, and other healthcare professionals involved in medication management.

Intervention

the intervention can consist of several integrated technologies:

1. Ai-supported prescribing

an ai-enabled clinical decision-support system can evaluate medication orders and identify potential problems such as inappropriate doses, allergies, contraindications, drug–drug interactions, therapeutic duplication, and renal or hepatic dose

concerns.

2. Ai-based medication-risk prediction

machine-learning models can analyze patient characteristics, laboratory values, previous medication history, and clinical diagnoses to identify patients who may have an increased risk of adverse drug events.

3. Robotic dispensing

robotic pharmacy systems can automatically select, count, package, label, and organize medications. integration with electronic prescribing systems can reduce transcription and manual-selection errors.

4. Automated medication verification

barcode-based systems can verify medication administration against the electronic medication order. the system can generate an alert when the medication, patient, dose, route, or timing does not match the prescribed treatment.

5. Ai-assisted medication reconciliation

ai can compare medication histories from different sources and identify discrepancies between pre-admission medications, inpatient prescriptions, and discharge medications.

6. Monitoring of high-risk medicines

ai-based surveillance can identify potentially unsafe patterns involving high-alert medications, including anticoagulants, insulin, opioids, sedatives, and concentrated electrolytes.

Data collection

data can be collected from electronic health records, computerized physician-order-entry systems, pharmacy databases, medication-administration records, incident-reporting systems, and direct observation.

the following variables can be measured:

- number of medication errors per 1,000 medication orders
- prescribing errors
- dispensing errors
- administration errors
- drug–drug interaction alerts
- inappropriate-dose events
- allergy-related prescribing errors
- medication reconciliation discrepancies
- preventable adverse drug events
- pharmacist and nursing interventions
- alert acceptance and override rates
- medication turnaround time

- patient length of hospital stay
- medication-related readmissions
- medication-related mortality

Statistical analysis

medication-error rates before and after implementation can be compared using appropriate statistical tests. categorical outcomes can be analyzed using chi-square or fisher's exact tests, while continuous variables can be assessed using t-tests or non-parametric alternatives. multivariable regression can be used to adjust for patient age, comorbidities, hospital department, medication burden, and disease severity.

Results

because this is a research framework rather than a completed clinical trial, numerical results should not be fabricated. the expected findings are that integrated ai and robotic medication-management systems will reduce several categories of preventable medication errors.

ai-supported prescribing is expected to identify inappropriate prescriptions before medication administration. automated interaction checking may reduce clinically significant drug–drug interactions, while dose-support systems may reduce dosing errors associated with renal or hepatic impairment.

robotic dispensing is expected to reduce manual selection and counting errors and improve medication-labeling consistency. when combined with barcode verification, robotic medication

management may create multiple safety checkpoints between prescribing and administration.

ai-based medication reconciliation is expected to identify discrepancies between a patient's previous medication list and current hospital prescriptions. this may be particularly useful during admission, transfer between hospital departments, and discharge.

the overall effect can be evaluated through reductions in medication errors, preventable adverse drug events, pharmacy interventions, and medication-related hospital complications. however, excessive or poorly designed ai alerts may contribute to alert fatigue. therefore, the effectiveness of the system should be evaluated not only by the number of alerts generated but also by clinically meaningful errors prevented.

Discussion

the integration of ai and robotics into hospital medication management has the potential to transform medication safety from a predominantly reactive process into a more proactive system. conventional medication-management processes depend heavily on human attention and manual verification. although pharmacists, physicians, and nurses remain essential, technology can provide additional safety barriers.

ai can support clinical reasoning by rapidly processing patient-specific information. for example, an ai system can compare a medication order with allergies, laboratory results, current medications, diagnoses, and dosing recommendations. this does not mean that ai should independently prescribe medication. instead, ai should function as a decision-support

tool in which qualified healthcare professionals retain clinical responsibility.

robotics can reduce repetitive manual tasks. robotic dispensing and medication-preparation systems may improve standardization and reduce opportunities for selection, counting, labeling, and transcription errors. automated systems can also provide electronic records that improve traceability and accountability.

the combination of ai and robotics may be more effective than either technology alone. ai can identify a potential medication problem, while robotic systems can help ensure that the validated medication order is accurately prepared and delivered. barcode verification can then provide another checkpoint before administration.

despite these benefits, several limitations must be considered. ai systems may produce false-positive or false-negative alerts. biased or incomplete training data may reduce performance in certain patient populations. excessive alerts can lead to alert fatigue and cause clinicians to override important warnings. robotic systems can also experience technical failures and require maintenance, validation, and backup procedures.

cybersecurity and patient privacy are additional concerns because ai-enabled medication systems depend on electronic health information. hospitals should implement strong access controls, audit trails, encryption, system validation, and procedures for responding to technical failures.

Conclusion

ai and robotics have substantial potential to reduce pharmacological misuse and medication-related harm in hospitals. ai can support safer prescribing, medication reconciliation, interaction detection, dose optimization, and risk prediction, while robotics can improve dispensing, preparation, verification, and medication distribution. the safest approach is not to replace healthcare professionals but to create a human–technology safety system in which ai and robotics provide additional verification and decision-support layers.

future research should use prospective multicenter studies to determine whether integrated ai and robotic medication systems reduce clinically significant medication errors, preventable adverse drug events, hospital length of stay, and medication-related mortality. implementation should also evaluate cost-effectiveness, staff acceptance, alert fatigue, cybersecurity, and the reliability of ai recommendations.

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